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Muskmelon Grafting as an Approach to Control *Monosporascus cannonballus* Wilt under Greenhouse and Geothermal Conditions in the South of Tunisia

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ABSTRACT

Monosporascus cannonballus is a destructive soil-borne pathogen which is able to destroy an entire muskmelon crop early in the cropping season, in greenhouses heated with geothermal water, in the south of Tunisia. Soil fumigation with methyl bromide seems to be the most common approach for controlling *Monosporascus* of melons in some regions of the world. Likewise, grafting melons and watermelons on *Cucurbita* rootstocks is successfully used to manage soil-borne pathogens (Fusarium wilt) in Tunisia and in many others countries. In this study, two muskmelon varieties "Pancha" and "Protéo" of S&G Company were grafted on three rootstocks: Strong Tosa (S&G) and TZ 148 (Tezier) of hybrid *Cucurbita* type and Emphasis of *Lagenaria* type and planted in an early season, under greenhouse and in geothermal conditions, in the South of Tunisia. Results showed that grafting "Pancha" and "Protéo" on the rootstocks Strong Tosa and TZ 148 enhanced plant growth (leaf area and dry matter) and increased early and total production as well as the weight of fruits, compared to control treatments but grafted plants are wilted later at the end of the culture.

Keywords: early crop, melon, soil-borne pathogen, wilting

INTRODUCTION

The wilting disease of muskmelon is an endemic disease due to *Monosporascus cannonballus*. It has been observed in geothermal cultures of melon in Tunisia, which account for 26.85 ha in 2007 among 163 ha for all the geothermal cultures (Tunisian Ministry of Agriculture and Water Resources), in the regions of Kébili, Tozeur and Gabès. This disease was first observed in Tunisia by Martyn in 1983 then the pathogen was noted for the first time on watermelon roots in 1994 (Martyn *et al*. 1994) and isolated for the first time on muskmelon roots by Hamza in 2002.

This phenomenon is known in several semi-arid warm regions in the world, in India, in the South of Spain, in the South of the United States, in Saudi Arabia, in Japan and in Israel (Cohen *et al*. 2000).

This disease is severe in geothermal cultures of melon in Tunisia and can destroy all cultures in early as well as in late cropping seasons. *M. cannonballus* provokes withering and drying of affected plants causing wilting and root necrosis (Hamza 2002). This disease was reported in other regions by other authors as Root Rot/Vine Decline or RRVD (Martely *et al*. 1991; Martyn and Miller 1996). RRVD caused by *M. cannonballus* was studied by Martyn and Miller (1996) who described the biology, the pathology and the epidemiology of the disease indicating that the mycelium growth of *M. connonballus* is optimal at temperatures ranging from 25° to 35°C at pH 7. It is completely inhibited at 20°C and 45°C. *In vitro* tests of some fungicides showed inhibition of the growth of *M. cannomballus* by maneb, mancozeb and benomyl (Hamza 2002). Control methods used in some countries are essentially based on fumigation by the methyl bromide and grafting (Cohen *et al*. 2000).

The grafting of vegetables is commonly used in Japan, Korea, Mediterranean Basin and some countries in Europe to control some soil-borne diseases (Lee 1994). The grafting of melon has especially been used against different races of *Fusarium oxysporum* sp. *melonis* (Edelstein *et al*. 1999) whereas, to our knowledge, grafting was not fully tested against *M. cannonballus*.

In Tunisia, the grafting technique of muskmelon and watermelon on stocks of *Lagenaria sciceraria* type and gourd type (*Cucurbita maxima* × *Cucurbita moshata*) protected plants against *Fusarium solani* and *Fusarium oxysporum* and improved the quantitative and qualitative characteristics of both tested cucurbits (Jebari 1994; Chouka-Aounallah and Jebari 1997; Aounallah *et al*. 2002). In fact, grafting limited plant mortality, improved the growth, the total production per plant and the precocity of the grafted plants. The quality of fruits quantified by the refractometric index (°Brix) remains unchanged as confirmed by other authors comparatively to the commercial hybrid stocks of gourd type (Lee 1994; Trionfetti Nisini *et al*. 2002). Thus, the major objective of the present study was to assess the behaviour of several melon varieties grafted on different rootstocks against *M. cannonballus* based on some agronomic criteria and wilt severity.

MATERIALS AND METHODS

This assay was conducted in a soil naturally infested by RRVD agent under a plastic greenhouse heated with geothermal water in the region of El Hamma situated in the South west of Tunisia.

Two varieties of melon were used in this experiment: Pancha F1 which is the most cultivated variety in the region and Protéo F1 of S&G of Charentais type.

Both these varieties were grafted on three rootstocks: Emphasis of S&G of *Lagenaria sciceraria* type, Strong Tosa (St) of S&G and TZ 148 (TZ) of Tezier, both of hybrid gourd type.

The following treatments were applied:
- Non-grafted Pancha
- Pancha/ST: Pancha grafted on Strong Tosa

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- Pancha/TZ: Pancha grafted on TZ 148
- Pancha/Emp: Pancha grafted on Emphasis
- Non-grafted Protéo
- Protéo/ST: Protéo grafted on Strong Tosa
- Protéo/TZ: Protéo grafted on TZ 148
- Protéo/Emp: Protéo grafted on Emphasis

The sowing of varieties and rootstocks was realized in a professional nursery at the end of January in plastic jars filled with compost. The grafting was realized two weeks later, at the stage with two true leaves, following the method by Anomymous (1991). Plants were then transferred to the greenhouse under controlled conditions. After plant acclimatization, the assay was set up on February 25th, 2004, at the stage of four true leaves. The greenhouse where the experiment was carried out was equipped with a fertigation system and heated with geothermal water. The greenhouse was divided into four elementary plots 15 m long × 8.5 m wide which represented four replicates of the assay. Every elementary plot represented 4 lines of plants 0.5 m wide with a 1.5 m space between lines. Every treatment was represented by a line with 30 plants. Cultural techniques usually employed by farmers were applied in the greenhouse. After plantation, the majority of plants of both varieties grafted on Emphasis withered, probably due to *Pythium*. The survived plants remained weak until the end of the culture cycle, probably due to a bad affinity between the rootstock and the graft. Consequently, results of both treatments are not available.

The parameters noted in this essay are:

- The withering rate determined by counting the number of plants affected by *M. cannonballus*. This parameter was followed by the appearance of the disease, twice a week, until the end of the culture cycle. For every treatment and repetition, the withering rate was obtained by dividing the number of plants withered by the total number of plants.
- The plant height was measured 42 days after plantation. An average of 10 plants was calculated per treatment and per repetition.
- Mean length of the internodes represented the average length of 10 internodes (counted from the base to the 10th internode) per treatment and per repetition.
- The number of male and female flowers per plant was noted once a week during the flowering period of the culture, between the 48th and the 76th day after plantation. The average of 10 plants was calculated per elementary treatment and per repetition.
- Dry weight of the aerial part of the plant: 10 plants per treatment and per repetition were taken just after the last harvest. These were weighed; then a sample was taken and dried at 60°C until a constant weight was obtained.
- Early production by plants was noted, per treatment and per repetition, 15 days after the beginning of the harvest.
- Total production by plant, per treatment and per repetition.
- Average weight of fruits.
- Average number of fruits per plant.

The results obtained in this study were statistically analyzed by analysis of variance (ANOVA) using Statitcef software. When a significant difference ($P<0.05$) between treatments was detected, the Newman-Keuls test was applied to compare the means.

RESULTS

Effect of grafting on plant growth

Effect of grafting on plant height

The plant heights measured 42 days after plantation are represented in **Fig. 1**. The difference between grafted plants and non-grafted plants was statistically highly significant. The rootstocks we used increased the plant height by 64-74% in comparison to non-grafted plants.

Effect of grafting on internode length

According to **Fig. 2**, the length of internodes of the grafted plants was significantly higher than those of the non-grafted ones. For this parameter, the differences between both rootstocks used were not statistically significant.

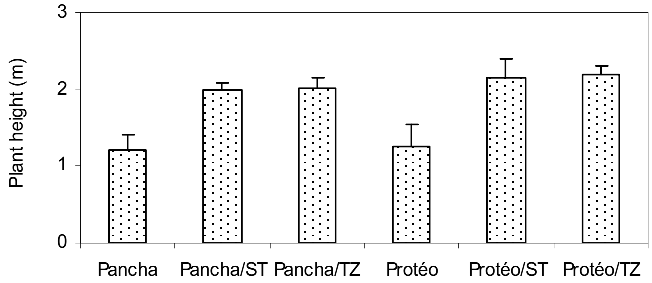

Fig. 1 Effect of grafting on plant height.

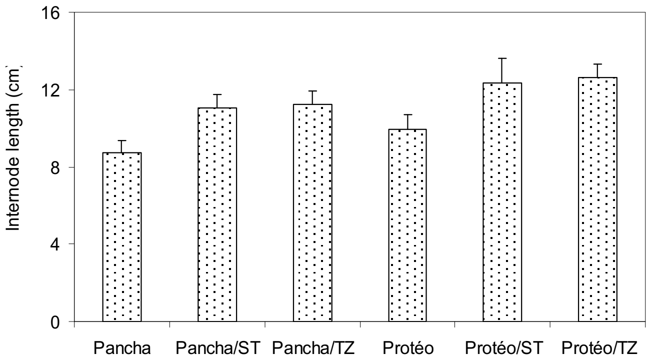

Fig. 2 Effect of grafting on internode length.

Effect of grafting on number of flowers

Fig. 3 shows the total number of male and female flowers per plant counted during this period. Statistical analyses revealed that both rootstocks used had significant effects only on the number of female flowers, while the number of male flowers was comparable for all tested treatments. So, the differences between both rootstocks used were statistically insignificant. The number of female flowers produced by plant increased by 75% and 98%, respectively in stock ST, for both varieties, Pancha and Protéo. In the case of stock TZ, this increase was even larger, and increases of 122% and 118% were registered.

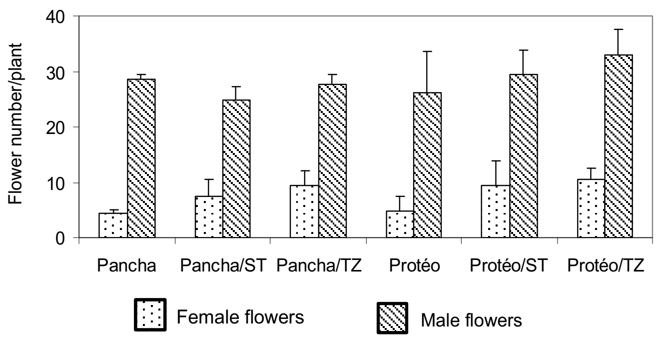

Fig. 3 Effect of grafting on the number of flowers.

Effect of grafting on dry material

The dry matter production of the aerial part of the plant was improved by grafting (**Fig. 4**). The differences between treatments were statistically significant. For variety Protéo, rootstocks ST and TZ increased the production in dry material by the plant, 3.5 and 2.8 times more, respectively than non-grafted plants while for variety Pancha and under similar conditions, the dry matter production was improved 2.3 and 3.2 times for ST and TZ, respectively.

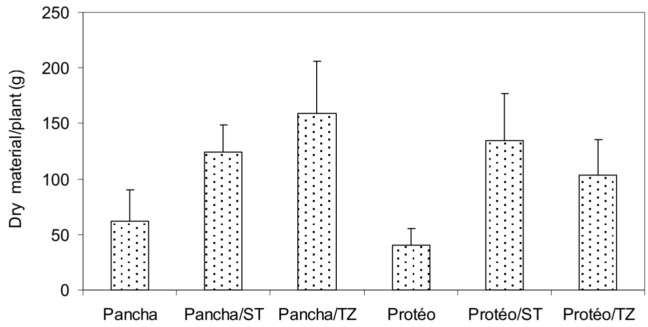

Fig. 4 Effect of grafting on dry material.

Effect of grafting on production parameters

Effect of grafting on total production

A very high significant improvement of the total production by plants was registered following the use of grafting (**Fig. 5**). This improvement was more marked in the case of variety Protéo in which production was seven times greater the non-grafted control when grafted (0.3 kg/plant for Protéo vs. 2.2 kg/plant for Protéo/ST and Protéo/TZ, respectively). For variety Pancha, and in the same trial conditions, the production was four times greater for both rootstocks used (0.5 kg/plant for Pancha vs. 2.0 and 2.2 kg/plant for Pancha/ST and Pancha/TZ, respectively). However, no significant difference was observed between both rootstocks.

Effect of grafting on early production

Early production is a very important agronomic parameter to judge the utility of grafting. For this reason, early production was quantified during the first two weeks of harvest. According to **Fig. 6**, grafting improved early production by plants very significantly. For total production, the differences were more marked in the case of variety Protéo for which the production of the non-grafted plants was almost nil during this period while for the grafted plants productions of 1.3 and 1.2 kg/plant were recorded for Protéo/ST and Protéo/TZ, respectively. For variety Pancha, early production increased 5-fold in grafted plants comparatively to non-grafted ones (0.24 kg/plant for Pancha vs. 1.2 and 1.3 kg/plant for Pancha/ST and Pancha/TZ, respectively). Furthermore, grafting advanced precocity by one week. Thus, the harvest began one week later in the case of both varieties for non-grafted plants (21/05) in comparison to grafted plants (14/05).

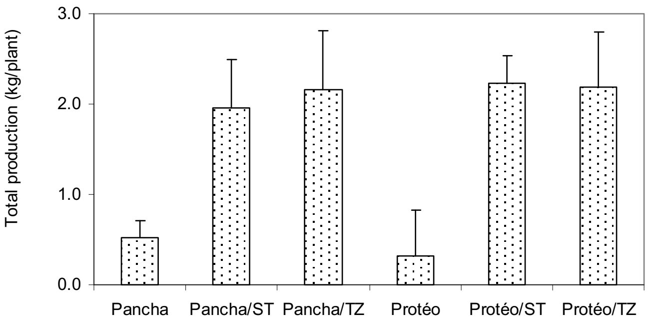

Fig. 5 Effect of grafting on total production.

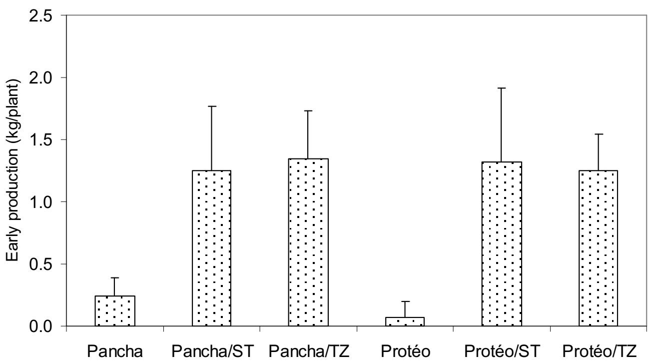

Fig. 6 Effect of grafting on early production.

Effect of grafting on number of fruits

The number of fruits per plant was highly affected by grafting (**Fig. 7**). For this parameter, the differences are also more marked in the case of variety Protéo where this number was 5 times higher in grafted than in non-grafted plants (0.35 fruit/plant for Protéo vs. 1.78 and 1.80 fruits/plant for Protéo/ST and Protéo/TZ, respectively). However, for variety Pancha, the number of fruits per plant was 3 times higher in grafted plants (0.86 fruit/plant for Pancha vs. 2.24 and 2.26 fruits/plant for Pancha/ST and Pancha/TZ, respectively).

Effect of grafting on average weight of fruits

Both the tested rootstocks significantly affected the average weight of fruits and this for both varieties of melon used in this assay (**Fig. 8**). For this parameter, the differences between both rootstocks were not significant. The average fruit weight was improved by 43% and 51% for variety Pancha grafted on ST and TZ, respectively, or 52% and 47%, respectively for variety Protéo.

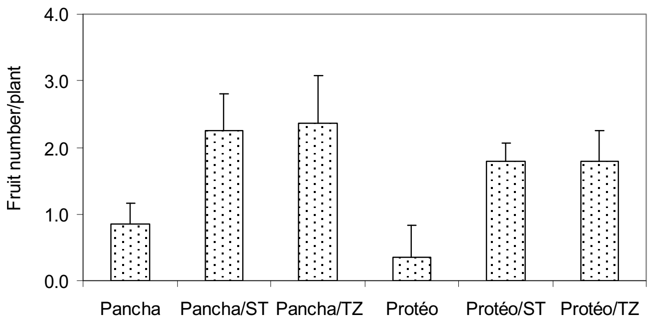

Fig. 7 Effect of grafting on the number of fruits.

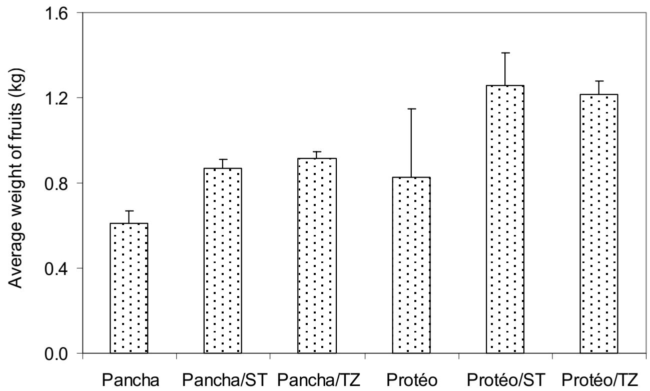

Fig. 8 Effect of grafting on the average weight of fruits.

Effect of grafting on withering rate of plants

The rate of withering was periodic since the appearance of the first symptoms of the disease. The results we obtained are grouped in **Fig. 9**. The first withered plants were observed 68 days after plantation. Besides, the disease developed on all the treatments applied. However, both rootstocks we used could obtain a certain resistance to the disease for both varieties used. In fact, at the beginning, the number of withered plants increased in the same way for all

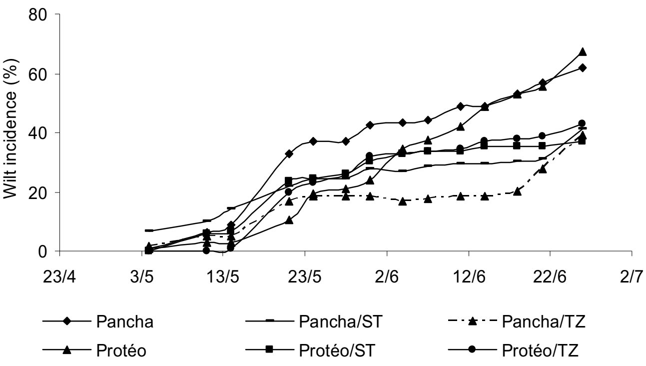

Fig. 9 Effect of the grafting on withering rate of the plants.

treatments; then the rate of wilting remained almost constant for the grafted plants and it ended its increase until the end of culture for non-grafted plants. At the end of the culture cycle (last harvest 26/06) both rootstocks used reduced the rate of wilting in a significant way (34% and 37% for variety Pancha and 45% and 36% for variety Protéo grafted on ST and TZ, respectively).

DISCUSSION AND CONCLUSION

The disease of sudden withering of melon caused by *Monosporascus cannonballus* is of a very destructive nature and which has become very pronounced under greenhouse culture in geothermal conditions in the south of Tunisia.

The results of this study revealed that there is an incompatibility between melon and some rootstocks of *Lagenaria sciceraria* type as Emphasis used in this test leading to a high plant mortality soon after plantation and the plants that did survive remained weak until the end of the culture period. However, this type of rootstocks has been used with success with the watermelon to control *Fusarium oxysporum* f. sp. *niveum* (Lee 1994; Aounallah *et al*. 2002). This kind of incompatibility between melon and some rootstocks types have been also signaled by Trionfetti *et al*. (2002) in the case of *Fusarium oxysporum* f. sp. *melonis*.

The two rootstocks Strong Tosa (ST) and TZ 148 (TZ), which are hybrids of gourd type, improved the vegetative growth (plant height, internodes length, flowers number and dry matter of the plants), production, and fruit quality (early and total production per plant, fruits number and caliber). Cook and Baker (1983) indicated that the grafted plants develop a more vigorous root system that absorb water and mineral elements more efficiently in comparison with non-grafted plants; their root system also serves as a supplier of endogenous hormones to the plant. However, no significant difference has been noticed between the agronomic performances of both tested rootstocks. Our results, which focus on the improvement of vegetative growth and on production following the application of grafting, corroborate those obtained by Lee (1994), Jebari (1994), Edelstein *et al*. (1999) and Cohen *et al*. (2000) on melon and those of Trionfetti *et al*. (2002) and Chouka and Jebari (1997) on watermelon. However, Cohen *et al*. (2000) obtained better results in the field rather than under greenhouse tests.

The withering rate induced by *M. cannonballus* decreased by grafting but no true resistance of the rootstocks was observed in this test. As found by Mertely *et al*. (1993) and Uematsu *et al*. (1993), the disease developed on grafted plants but the noted tolerance was rather due to the root system vigor than resistance to the pathogen as also mentioned by Cohen *et al*. (2000).

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